

Probabilistic Quantitative Precipitation Forecasts Product/Service Description Document

Part I - Mission Connection

NOAA's Strategic Plan states that we are to "Improve the reliability, lead-time, and effectiveness of weather and water information and services that predict changes in environmental conditions." To support that effort, The National Weather Service Strategic Plan for 2005 – 2010: Working Together to Save Lives, establishes a mission goal to "develop new capabilities and move into a new direction of forecasts... and expand beyond traditional weather and water products...."

(http://www.weather.gov/sp/NWS_strategic_plan_01-03-05.pdf)

In response to the NOAA and NWS goals, the Weather Forecast Office in Tulsa, Oklahoma (TSA) has developed a method to provide probabilistic quantitative precipitation forecasts on a routine basis, in the form of probability of exceedance (POE) forecasts. This method will be used at several Weather Service Forecast Offices (WFOs) in the Southern Region. These POEs will provide our clients and customers with more detailed precipitation forecasts that they can use in their decision-making processes.

a. Product Description

Forecasts for the probability to exceed particular rainfall amounts are being produced through the Gridded Forecast Editor (GFE) developed by the Global Systems Division (formerly Forecast System Laboratory, Boulder, CO). These forecasts are created using forecasts of the probability of precipitation, the quantitative precipitation forecast, and the exponential distribution density function. The probabilities to exceed 0.10, 0.50, 1.00 and 2.00 inches of rain are provided for each 6-hour period during the first 96 hours of the forecast cycle. These forecasts are provided as both tables and bar charts for each county in each participating WFO's forecast area.

b. Purpose and Intended Use

The purpose of the POE forecast is to provide a greater level of detail to all customers and partners. It has been shown (Amburn, 2006) that forecasters have sufficient knowledge of precipitation events to allow them to inform users of their probability to exceed certain rainfall threshold values. Over time, it is expected that customers will be able to use the POEs to help mitigate economic losses, maximize economic gains, and help protect life and property.

c. Audience

The audience for the POE forecasts includes NWS internal users, federal, state, and local emergency management agencies, mitigation and risk management specialists in all sectors of society, farmers, the media, and all others in need of information on the probability to exceed certain rainfall amounts. This product will be available to all who have an Internet connection.

d. Presentation Format

The POE forecasts are available on the Internet and will consist of locally produced charts and tables. Each POE table and bar chart (see Appendix) displays the probability

to exceed threshold rainfall amounts of 0.10, 0.50, 1.00 and 2.00 inches of rain in a 6-hour time period. A map of the forecast area is also available which displays the gradient of the probability to exceed one inch of rain in each 6-hour period during the first 24 hours of the Hazardous Weather Outlook.

e. Feedback Method

Comments regarding the POE forecasts should be sent to the feedback email address on the Web page containing the product, and to the generic NWS Headquarters Customer Survey link:

www.weather.gov/survey/nws-survey.php?code=PQPF

Comments and suggestions will be solicited for a period of six months, during which time a proactive effort will be made to educate potential users and partners of the product availability.

Part II – Technical Description

a. Format and Science Basis

It has been established that the gamma distribution, specifically a special case of the gamma distribution called the exponential distribution, provides a reasonable approximation for the distribution of rainfall amounts (Wilks, 1995). An ESSA Technical Memorandum (Jorgensen and Klein, 1969, hereafter J&K69), based on 15 years of data, showed similar results. Finally, a recent study (Amburn, 2006), based on 10 years of data in eastern Oklahoma and northwest Arkansas again confirmed that the distribution of rainfall amounts for a given event were well represented by the exponential distribution.

The Amburn study used the exponential distribution probability density function (PDF) to approximate the probability to exceed (POE) any selected rainfall amount (x). The unconditional POE(x) for any point and event is given by:

$$uPOE(x) = PoP * e^{(-x/\mu)} \quad (1)$$

PoP is the National Weather Service probability of precipitation, x is the selected exceedance value, and μ is the National Weather Service quantitative precipitation forecast (QPF). When the QPF is substituted for μ , it effectively changes the shape of the exponential PDF, therefore raising or lowering the probability to exceed selected rainfall amounts. This is shown in Figure 1.

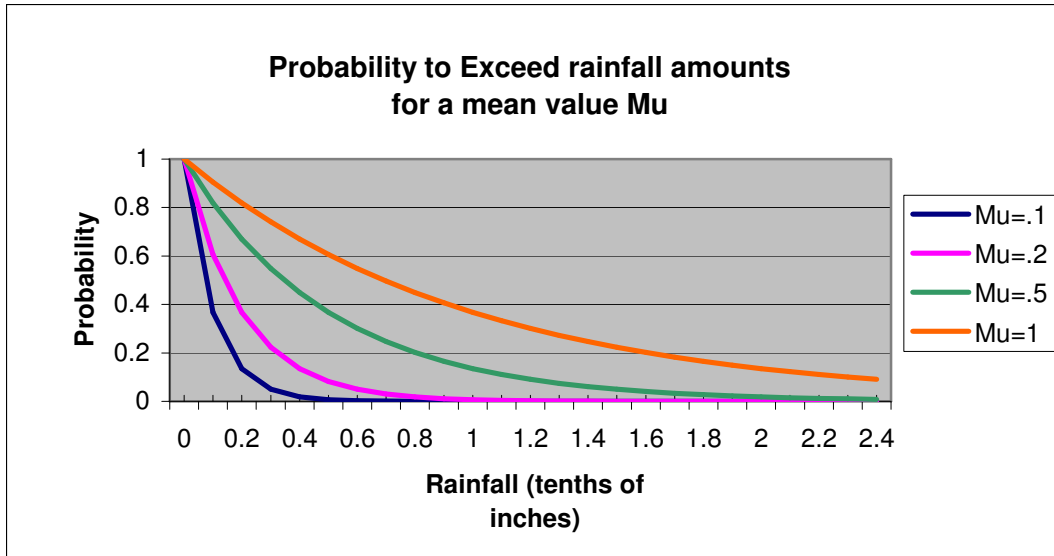


Figure 1 Exponential distribution PDFs for different values of μ (μ in equation 1). μ and NWS QPFs are assumed to be equivalent.

Results of the POE equation were compared to the findings of J&K69, using their 12-hour precipitation means for μ in the uPOE equation. J&K69 computed the probability to exceed certain rainfall amounts for 108 observation stations across the conterminous United States based on the climatology at those stations. Comparisons to the POE equation were quite good (Table 1). Figures 2 through 5 show comparisons of the uPOE and J&K69 results for Washington D.C.

Table 1. Sample POEs for 0.25 and 0.50 inches as taken from J&K69 and also calculated from uPOE equation (6) using 100% for the PoP. Average difference between methods was 3.38%. A maximum difference was 8% at Detroit and Fort Worth.

City	Mean	J&K(.25)	uPOE(.25)	J&K(.50)	uPOE(.50)	Avg Diff
Detroit (winter)	0.11	13%	10%	4%	1%	3.00%
Detroit (spring)	0.14	22%	16%	6%	3%	4.50%
Detroit (summer)	0.25	29%	37%	16%	14%	5.00%
Detroit (autumn)	0.20	26%	28%	11%	8%	2.50%
Fort Worth (winter)	0.19	24%	27%	11%	7%	3.50%
Fort Worth (spring)	0.39	47%	53%	27%	28%	3.50%
Fort Worth (summer)	0.32	38%	46%	21%	21%	4.00%
Fort Worth (autumn)	0.30	38%	43%	18%	19%	3.00%
Atlanta (winter)	0.30	37%	43%	19%	19%	3.00%
Atlanta (spring)	0.36	44%	50%	27%	25%	4.00%
Atlanta (summer)	0.34	43%	48%	24%	23%	3.00%
Atlanta (autumn)	0.25	34%	37%	19%	14%	4.00%
Sacramento (winter)	0.24	32%	35%	14%	12%	2.50%

Sacramento (spring)	0.19	28%	27%	8%	7%	1.00%
Sacramento (summer)	0.11	14%	10%	7%	1%	5.00%
Sacramento (autumn)	0.26	36%	38%	18%	15%	2.50%
					Avg Diff	3.38%

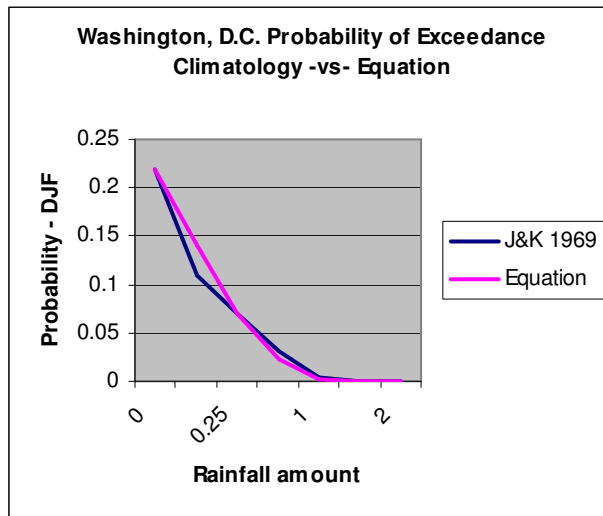


Figure 2. Plot of POEs for Washington D.C. for the December, January and February season, using results of the uPOE equation and those of J&K69.

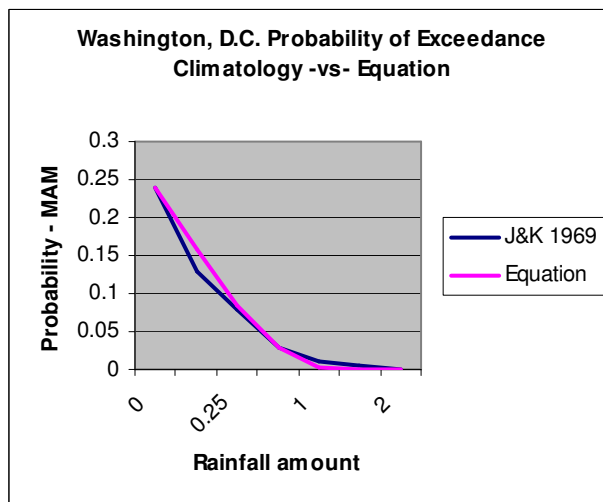


Figure 3. Same as Fig 2 but for the March, April and May season.

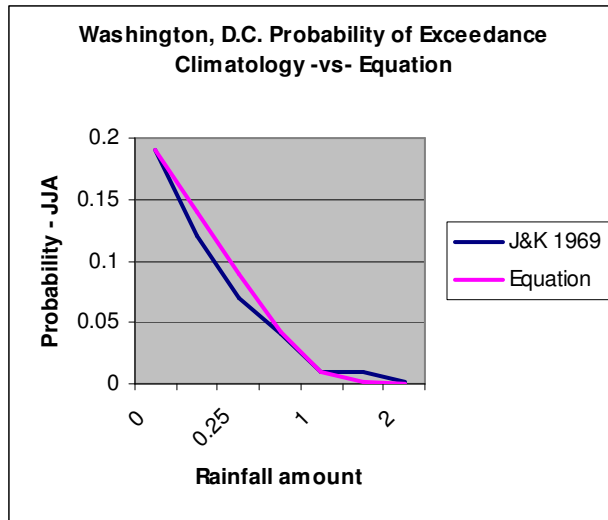


Figure 4. Same as Fig 2, but for the June, July and August season.

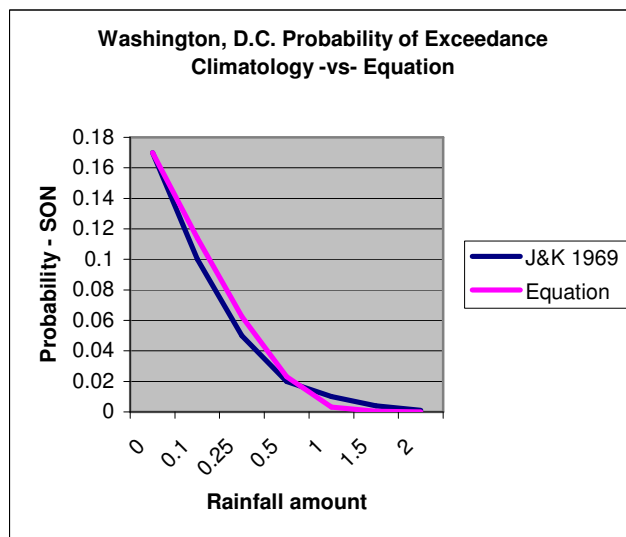


Figure 5. Same as Fig 2, but for the September, October, November season.

In practice, the WFO QPF (which is unconditional) is converted to a conditional QPF. This is accomplished by dividing the unconditional QPF by the WFO PoP. The new conditional QPF is used for μ in the POE equation and multiplied by the PoP to arrive at the unconditional POE. Figures 6 through 8 show verification of actual events in the WFO Tulsa forecast area. The 12-hour climatological average precipitation from J&K69 was used in the uPOE equation and is labeled “Climo Fcst uPOE.” The WFO QPF was also used in the uPOE equation (WFO Fcst uPOE). In each case, the observed PoP (determined by areal coverage) was used in equation (1). A perfect forecast uPOE was also computed using the observed areal average precipitation amount and the observed PoP. Distributions of rainfall amounts were plotted and labeled as the “actual uPOE.”

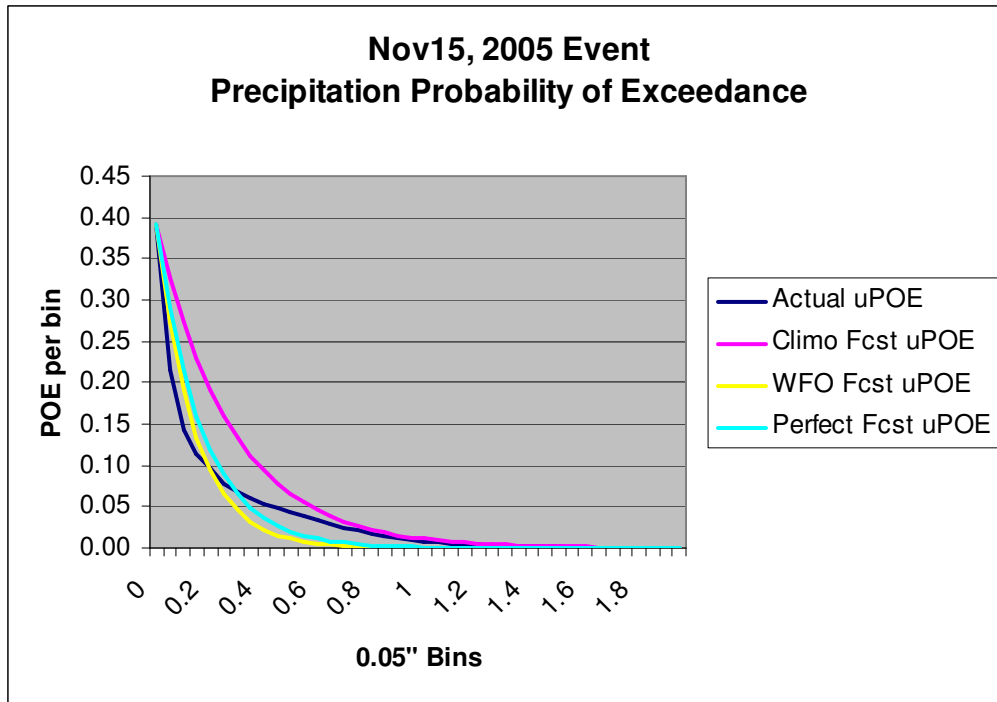


Figure 6. November 12-hour precipitation event. Precipitation distribution shown as the "actual uPOE." All other POEs as labeled.

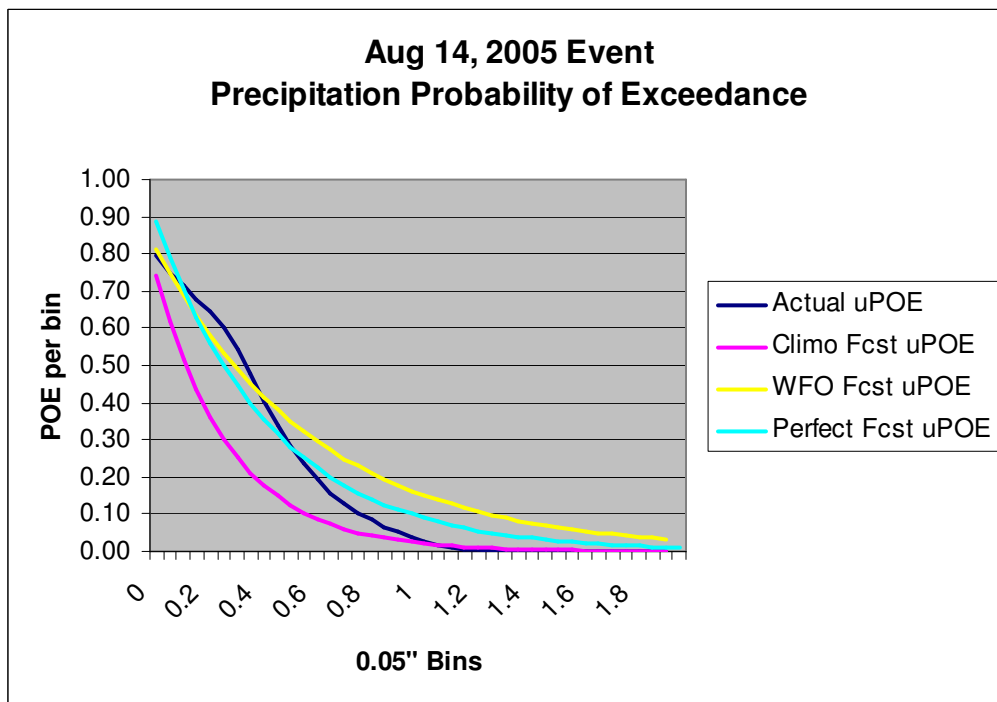


Figure 7. Same as Fig 6 but for an August event.

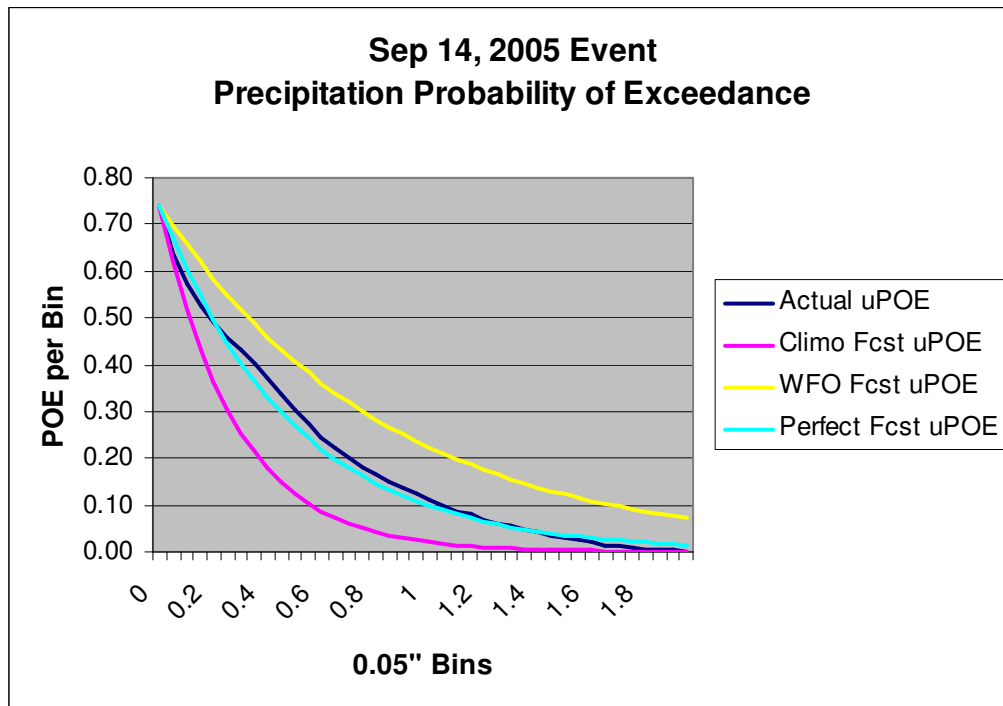


Figure 8. Same as Fig 6 but for a September event.

Both the comparisons to the J&K69 study and the comparisons to actual events indicate the uPOE equation can provide significant and reasonably accurate forecast information to our customers and partners.

b. Product Availability

The uPOE forecasts will be available on the WFO TSA Internet site continuously and updated at least every 12 hours when the routine forecast package is created and disseminated. Updates will be available anytime there are changes in the PoP or QPF forecasts.

c. Additional Information

1. The product was created by Steve Amburn (SOO) and Jamie Frederick (IT) at WFO Tulsa, Oklahoma. The public forecasters at each participating WFO will routinely produce the uPOE products through the GFE in AWIPS.
2. A GFE tool will automatically create the uPOE forecasts from the PoP and QPF provided by WFO forecasters.
3. No special software is necessary to display the forecasts. They are available via the Internet as both graphic and alphanumeric products.

Part III - References:

Amburn, Steven A., and J.M. Frederick, 2006: *An Experiment in Probabilistic Quantitative Precipitation Forecasting*, , 18th Conference on Probability and Statistics, 86th Annual Meeting of the American Meteorological Society, Atlanta, GA, January 2006.

Jorgensen, D.L. and W.H. Klein, 1969: *Conditional Probabilities of Precipitation Amounts in the Conterminous United States*. ESSA Tech. Memo, WBTM TDL 18, U.S. Dept. Commerce, 89 pp. [NTIS PB 183144]

Wilks, Daniel S., 1995: *Statistical Methods in Atmospheric Sciences*, Academic Press, San Diego, CA, 467 pp.